PHYTOTOXICOLOGY 1995 INVESTIGATION:

AMERICAN STANDARD

CAMBRIDGE

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Executive Summary

The investigation in 1995 confirmed the results of earlier phytotoxicology studies that boron and fluoride are primary contaminants emitted from A-S in Cambridge. Concentrations of boron in foliage and soil, and of fluoride in foliage, exceeded MOEE guidelines at sample sites close to A-S. Foliar injury typical of boron and fluoride was the most distinctive and severe on vegetation at sites within 250 m of the company.

Twelve sites had a foliar boron concentration greater than the ULN. Four foliage sites also exceeded the fluoride ULN and one foliage site marginally exceeded the molybdenum ULN. Soil levels of total boron at seven sites, of barium at two sites, and of strontium and zinc at one site, exceeded ULN or OTR guidelines.

HWE boron concentrations in soil at most sites within 500 m of A-S exceeded the MOEE guideline. The elevated soil boron levels are potentially phytotoxic and have contributed to the elevated foliar boron concentrations and injury in the survey area. However, it is unknown to what degree, as elevated levels in foliage also can result from exposure to atmospheric boron. The fact that the surface soil at most sample sites had excessive HWE soil boron concentrations that were similar or marginally higher than 1989, and that some sites not exceeding the soil boron guideline still had foliar boron levels above the ULN, indicates that A-S is an ongoing atmospheric emitter of boron. The higher foliar levels of boron and other elements at sample sites in the immediate A-S area, together with the significant statistical correlations between boron and these elements in foliage, indicates that A-S is a source of barium, cobalt, nickel, copper and zinc emissions in addition to boron and fluoride. Fluoride emissions may have increased in 1995, whereas emissions of boron and other elements likely have not changed considerably since the 1989 survey.

Although boron retention mechanisms in soil are not clearly understood, because the subsurface HWE boron concentrations at sites within 500 m of A-S were, on average, about twice as high in 1995 than in 1989, it would appear that A-S emissions over the last six years have increased the soil boron loading in the survey area. HWE boron concentrations in soil have reached the point where foliar boron injury on area trees would persist even if atmospheric boron emissions from A-S were completely abated.

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Phytotoxicology 1995 Investigation: American Standard, Cambridge

Introduction

Investigations in the vicinity of American Standard (A-S) in Cambridge were previously conducted by the Phytotoxicology Section in 1987, 1989, 1990 and 1991. In 1987, the Phytotoxicology Section investigated a complaint about severe vegetation injury in a City of Cambridge park, which was located directly across the Speed River from the A-S factory. Inspections of area vegetation revealed injury typical of boron and fluoride, and a pattern of decreasing injury with increasing distance from A-S, an indication that the injury was related to A-S emissions of boron and fluoride. The company uses compounds containing these and other elements in coating and finishing processes. MOEE staff of the Cambridge office met with A-S officials to discuss factory emissions and the company installed a water bath abatement system in their spray booths in order to reduce emissions. By December 1988, the water bath system was installed and operating. The investigations by the Phytotoxicology Section in 1989, 1990 and 1991 continued to reveal boron injury to vegetation, as well as elevated or excessive concentrations of boron, fluoride and other elements in tree foliage at sites close to A-S. In 1991, moss bags were used to monitor current A-S emissions of boron and other elements. Sharply elevated or excessive concentrations of boron, barium, titanium, fluoride, sodium, nickel and copper were found in moss at sites close to A-S. The moss data identified boron, copper, fluoride and nickel as primary contaminants, and barium, sodium and titanium as marginal contaminants. The 1989 to 1991 vegetation and moss data revealed that, in spite of the spray booth-related abatement measures undertaken in 1988, A-S continued to be a source of phytotoxic emissions.

In 1995, the MOEE Cambridge District office requested that the Phytotoxicology Section repeat the A-S investigation to determine the current status of boron and other elements in soil and vegetation in the vicinity of the company. This report presents the results of the 1995 Phytotoxicology investigation.

Investigation in 1995

On September 24 and 25, 1995, maple foliage was collected from 17 of the 28 sites sampled in previous years (Sites 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 14, 16, 17, 18, 19, 24 and 28), including distant Site 18 (upwind control). An additional tree was sampled in the vicinity of Site 1 (Norway maple), Site 16 (Norway maple), and Site 18 (Manitoba maple). At Site 1, the Amur maple sampled in previous years had been cut down and foliage from an adjacent Manitoba maple was collected. At all sites, duplicate foliage samples were collected from middle branches facing A-S, following standard Phytotoxicology sampling procedures. In addition, vegetation at all sites was inspected for boron and fluoride injury (see map of sample sites on page 7).

On October 25 1995, soil was collected from 13 sites (1, 2, 3, 5, 8, 9, 10, 12, 14, 16, 17, 18 and 28) at each of two depths (0-5 cm; 25-30 cm). Duplicate samples were collected at each depth. The exceptions were Sites 8, 12, 14 and 17, where only surface soil (0-5 cm) was collected because of difficulty sampling the hard-packed or stony subsoil (25-30 cm). The site maps for Sites 5, 12 and 17 were vague, and the soil from these sites may not have been collected from precisely the same area sampled in 1989.

Submission of Samples for Analysis

All foliage and soil samples were returned to the Phytotoxicology Section processing laboratory, where they were dried, ground, and stored in glass jars. All samples were then submitted to the MOEE's Laboratory Services Branch for analysis of boron, fluoride, and other elements, with the exception of fluoride in soil. The soils also were submitted for determination of available (hot water extractable - HWE) boron.

Results of Investigation

Observations

Table 1 summarizes the vegetation observations. Inspections in the survey area revealed characteristic boron injury on foliage of Norway maple and other tree species, including Amur maple, Manitoba maple, silver maple, red ash and chinese elm. Norway maple is particularly sensitive to boron. Foliar injury ranging from trace to severe was observed on Norway maple in the survey area. The most distinctive and severe boron injury was observed on tree foliage at or near Sites 1, 5, 8, 12 and 16, within 250 m of A-S. At these sites, the concentration of boron in foliage, and/or the HWE boron concentration in soil, was found to be excessive, an indication that boron was a primary causal agent. However, boron was not likely responsible for all of the observed injury in the survey area. Distant Sites 3 and 14, in particular, had foliage with severe injury, but neither the foliar boron level nor the HWE soil boron level were high enough to cause severe injury at either site. It is likely that some other factor, possibly moisture stress, had contributed to at least some of the injury at these sites, as well as other sites in the survey area.

Foliar injury typical of fluoride was observed on wild grape only at a few sites in the immediate area of A-S. The most severe injury was observed on grape foliage in the area of Site 12. Wild grape is extremely sensitive to fluoride, and the maple foliage data shows that fluoride is excessively elevated in vegetation in this area. Fluoride emissions may have contributed to the injury on Manitoba maple foliage at Sites 1 and 12, as Manitoba maple also is fluoride-sensitive, and fluoride was particularly elevated at both sites.

Analytical Results

The analytical results in the attached tables are compared with the distant control area (Site 18) and with the Upper Limit of Normal (ULN) urban guidelines developed by the Phytotoxicology Section. The Ontario Typical Range (OTR) guidelines have been substituted for the elements that have no ULN. ULNs reflect the expected upper limit of normal concentrations in urban areas not influenced by point sources of emissions (see Appendix A). OTRs are similar to ULNs but they are developed from a more extensive province-wide data base and so far they are only available for soil (see Appendix B). A level in excess of the background-based ULN or OTR guidelines indicates the likely presence of a source of contamination. All data in the tables are reported as µg/g (micrograms per gram, commonly referred to as ppm or parts per million).

Tree Foliage Results

Table 2 compares the foliar results for sites closer than 250 m, between 250 to 500 m, and greater than 500 m from A-S. Since all foliar results for beryllium and vanadium were below analytical detection limits they are excluded from the table. Foliar boron and fluoride concentrations were abnormally elevated especially at sample sites in the immediate area of A-S. Barium, molybdenum and nickel, and to a lesser degree chromium, cobalt, copper, lead, strontium, and zinc, also had higher concentrations at one or more sites close to A-S than at sites more distant. This pattern implicates A-S as a potential source. Pearson correlation coefficients revealed that the foliar boron concentrations were highly correlated ($p < 0.01$) with barium, cobalt, fluoride and nickel, and to a lesser degree ($p < 0.05$) with copper and zinc. The presence of a concentration gradient and a statistical correlation with boron strongly suggests that in 1995 A-S also emitted barium, cobalt, copper, fluoride, nickel and zinc. Foliar boron concentrations were not significantly correlated ($p > 0.05$) with chromium, lead, molybdenum and strontium. Correlations between boron and beryllium, boron and cadmium, and boron and vanadium were not performed because of consistently low levels and the absence of a concentration gradient from A-S.

A total of twelve foliage sites (1, 2, 3, 5, 8, 9, 10, 12, 14, 16, 17, 28) had a boron concentration greater than the ULN (175 µg/g), while four sites (1, 8, 9, 12) exceeded the fluoride ULN (35 µg/g). Site 12 had the highest foliar concentrations of both boron (1055 µg/g) and fluoride (170 µg/g), which were about 6 and 5 times the respective ULNs. The ULN for molybdenum was marginally exceeded at Site 16. Foliar concentrations of cadmium, chromium, cobalt, copper, lead, nickel, vanadium, and zinc were well within a

normal range at all sample sites. The results for barium and strontium, for which ULNs have not been established, were compared to the control site (Site 18). Relative to the control data, both elements were elevated at a few sample sites close to A-S.

Tables 3 and 4 compare the boron and fluoride data for the 13 sample sites that were common to each of the four survey years (1989, 1990, 1991 and 1995). In 1995, boron concentrations at most sites were slightly lower than in 1991, with Sites 1, 3, 5, 10, and 14 being the exceptions. The overall mean boron concentrations for the two closest data groups (0-250, 250-500 m) also were marginally lower but were not markedly different from the means of previous surveys. In contrast, fluoride at most sites increased in 1995 from 1991, with the concentrations at Sites 1, 2, 9 and 10 being the highest since 1989. Fluoride levels at Site 1 (130 µg/g) and Site 9 (67 µg/g) were about double the highest levels found at these sites in previous years. The overall mean fluoride concentrations for the two closest data groups also were the highest since sampling began.

The foliar results for the other elements (barium, copper, lead, nickel, and zinc) common to all years are summarized in Tables 5 through 9. Mean foliar concentrations of these elements were either similar to or slightly lower in 1995 compared to 1991. The overall mean foliar concentrations for each data group were not markedly different from the means of the previous three collections. The slightly lower lead and nickel concentrations were at least partly attributable to lower laboratory detection limits in 1995.

Soil Results

Total Concentrations in Soil

Table 10 shows the total soil concentrations of all elements, with the exception of beryllium. Beryllium was not detected in any of the soil samples. Boron was elevated in the surface soil (0-5 cm) at several sites within 500 m of A-S. Barium, cobalt, copper, lead, nickel, and zinc soil concentrations tended to be higher at sites in the immediate A-S area than at more distant sites. In relation to the background-based ULN or OTR guidelines, even the higher soil concentrations of most elements were well within a normal range, with the exception of barium (Sites 1 and 16), boron (Sites 1, 2, 8, 9, 12, 16 and 17), and zinc (Site 17), which exceeded the guidelines. The highest boron level (48 µg/g at Site 12) was about 3 times the ULN (15 µg/g), while the highest levels of barium (190 µg/g) and zinc (575 µg/g) only marginally exceeded the respective guidelines (160 and 500 µg/g). The data also revealed elevated levels of boron and strontium in the sub soil (25-30 cm) at Sites 1 and 10, respectively. However, the elevated strontium level at Site 10 only marginally exceeded the OTR and still lies within the data range from which the OTR was developed.

Table 11 compares the surface soil (0-5 cm) results for the elements common to both 1989 and 1995 from the same sample sites (2, 8, 9, 10, 16) within 500 m of A-S. Sites 1, 5, 12, and 17 are summarized separately because of the large disparity between the results and/or the uncertainty of the sampling location in 1989. In 1995, Sites 1 and 17 had markedly lower

soil concentrations of total boron and other elements. A tree had been cut down at Site 1 and relandscaping of the small front yard may have included new soil and/or sod resulting in the lower levels in 1995. The disparity at Site 17 is suspected to be due to different areas being sampled in 1989 and 1995 and, in part, to residual materials from some unknown industrial activity. Because of the highly variable soil metal levels in this area, Site 17 is not considered suitable for assessing impacts from A-S emissions.

The sample sites that are comparable (2, 8, 9, 10, 16) show that 1989 and 1995 concentrations of boron and other elements in the surface soil at each site, and the overall mean concentrations in each year, were not markedly different (marginally higher or lower mean concentrations were not likely significant). At Site 16, barium was slightly increased and marginally exceeded the OTR in 1995.

Available (Hot Water Extractable) Boron Concentrations in Soil

Available (HWE) boron concentrations were determined in the soils because boron in soil is water soluble and can be absorbed by tree roots and other vegetation. Once inside the plant, boron translocates to leaves and can result in elevated foliar levels and injury.

Boron was extracted from the soil using the MOEE's current hot water extraction (HWE) procedure (shown in Table 12 as *new method*). This revised procedure more accurately quantifies the available boron levels in soil compared to the old HWE procedure that was used prior to 1994. Both the new and old HWE methods were applied to the 1995 soil samples so the current results could be compared to 1989. The new HWE procedure is more efficient at extracting boron from soil. Therefore, the HWE soil guideline for boron was revised upwards from 1.0 µg/g to 1.5 µg/g. This soil guideline is based on phytotoxicity and soil HWE boron concentrations above 1.5 µg/g will cause injury to sensitive plants.

Table 12 shows that, with the new HWE procedure, nine of the ten sample sites within 500 m of A-S had an available boron level in surface soil and/or sub soil in 1995 that exceeded the revised Phytotoxicology guideline (1.5 µg/g). Site 1 had the highest levels (5.4 and 5.8 µg/g), which were about four times the guideline. Regardless of the extraction procedure, in 1995 the surface (0-5 cm) and subsurface (>25 cm) HWE boron concentrations were similar at each sample site. However, this was not the case in 1989. Using comparable extraction procedures (pre-1994 method), in 1989 the mean HWE boron concentration in surface soil from common collection sites within 500 m of A-S was about twice as high as the subsurface concentration (1.55 µg/g surface versus 0.72 µg/g subsurface). By 1995 there was no real difference in HWE boron concentrations between sample depths (1.37 µg/g surface versus 1.42 µg/g subsurface). There was a clear HWE boron concentration gradient in soil relative to A-S, with the highest levels occurring within about 250 m of the source. Similar HWE boron levels at surface and depth suggests that boron has been leached into the sub soil, and that boron is still being deposited on the surface as a result of current A-S emissions. In 1995, HWE boron levels exceeded the soil guideline at seven sites compared to four sites in 1989. In addition, the mean surface soil HWE boron concentration for

common sample sites within 500 m of A-S increased marginally from 1.32 µg/g in 1989 to 1.52 µg/g in 1995.

Table 13 summarizes the soil and foliage boron data and foliar injury at sites where both foliage and soil was collected in 1995. At most sites where foliage had elevated boron levels and injury, boron in the soil was available to plant roots at phytotoxic levels, particularly at sites within 500 m of A-S. This indicates that the elevated soil boron levels contributed to the foliar elevation and injury in the survey area. However, it is unknown to what degree the soil has contributed to the elevated foliar levels and injury, as elevated boron levels in foliage also can result from foliar uptake of boron from the air.

Conclusion

The investigation in 1995 confirmed the results of earlier phytotoxicology studies that boron and fluoride are primary contaminants emitted from A-S. Concentrations of boron in foliage and soil, and of fluoride in foliage, exceeded MOEE guidelines at sample sites close to A-S. Foliar injury typical of boron and fluoride was the most distinctive and severe on sensitive vegetation at sites within 250 m of the company.

Twelve sites had a foliar boron concentration greater than the ULN. Four foliage sites also exceeded the fluoride ULN and one foliage site marginally exceeded the molybdenum ULN. Soil levels of total boron at seven sites, of barium at two sites, and of strontium and zinc at one site, exceeded ULN or OTR guidelines.

HWE boron concentrations in soil at most sites within 500 m of A-S exceeded the MOEE guideline. The elevated soil boron levels are potentially phytotoxic and have contributed to the elevated foliar boron concentrations and injury in the survey area. However, it is unknown to what degree, as elevated levels in foliage also can result from exposure to atmospheric boron. The fact that the surface soil at most sample sites had excessive HWE soil boron concentrations that were similar or marginally higher than 1989, and that some sites not exceeding the soil boron guideline still had foliar boron levels above the ULN, indicates that A-S is an ongoing atmospheric emitter of boron. The higher foliar levels of boron and other elements at sample sites in the immediate A-S area, together with the significant statistical correlations between boron and these elements in foliage, indicates that A-S is a source of barium, cobalt, nickel, copper and zinc emissions in addition to boron and fluoride. Fluoride emissions may have increased in 1995, whereas emissions of boron and other elements likely have not changed considerably since the 1989 survey.

Although boron retention mechanisms in soil are not clearly understood, because the subsurface HWE boron concentrations at sites within 500 m of A-S were, on average, about twice as high in 1995 than in 1989, it would appear that A-S emissions over the last six years have increased the soil boron loading. HWE boron concentrations in soil have reached the point where foliar boron injury on street trees would persist even if atmospheric boron emissions from A-S were completely abated.

Foliage and Soil Collection Sites: American Standard (1995).

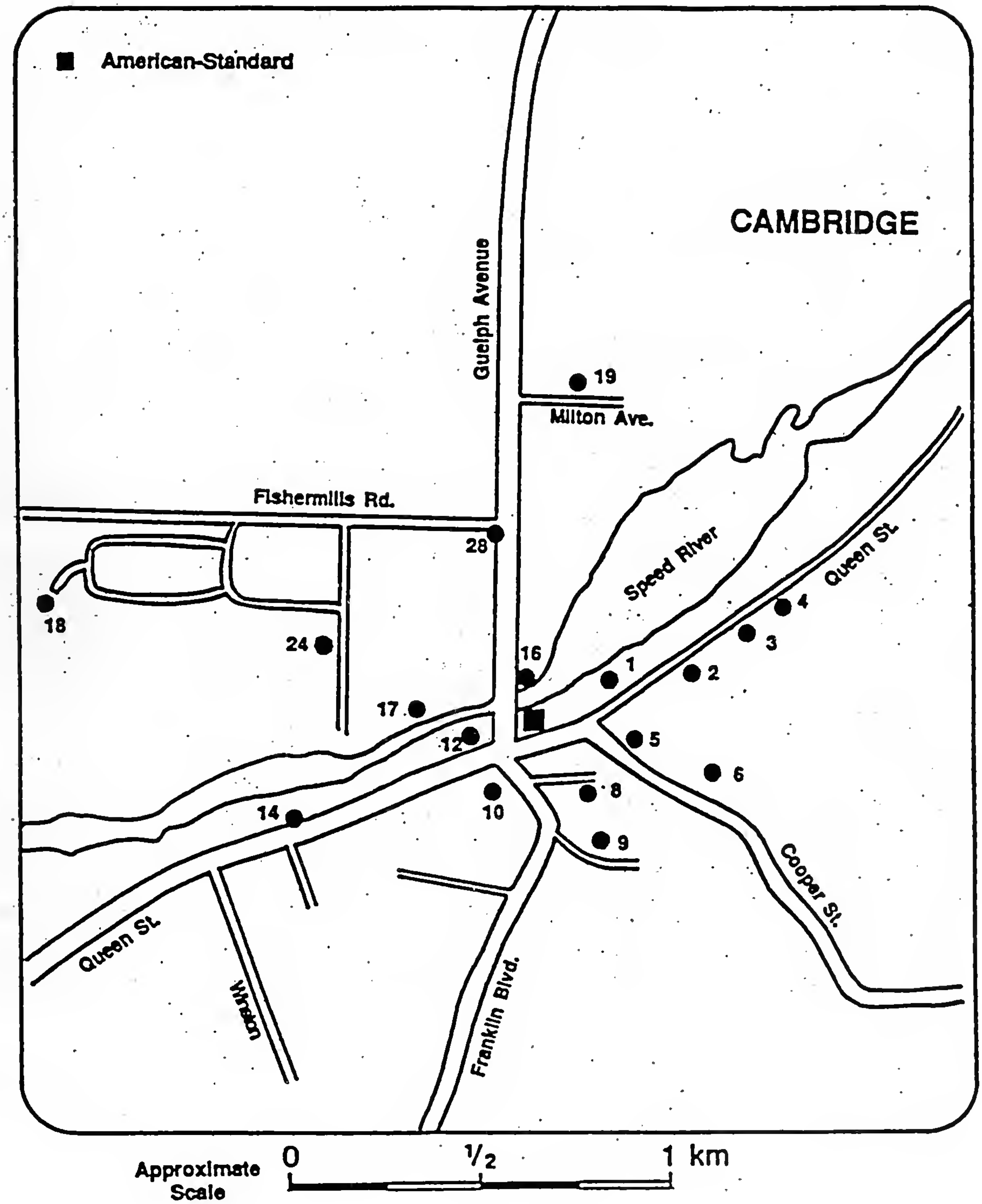

Table 1: Observed Injury to Vegetation: American Standard (1995).			
Site No.	**Distance from A-S in meters**	**Vegetation Examined**	**Observations**
1	200 m NE	Manitoba maple Norway maple Red Ash	T, M, I necrosis Light to Severe on older foliage T, M, I necrosis Moderate to Severe on all foliage T, M, I necrosis Light to Moderate on older foliage
2	400 m NE	Norway maple	T, M, I necrosis Light to Moderate on older foliage
3	600 m NE	Norway maple	T, M, I necrosis Light to Severe on most foliage
4	700 m NE	Silver maple Manitoba maple Norway maple	Foliage in normal condition Foliage in normal condition Foliage in normal condition
5	225 m E	Norway maple Manitoba maple Chinese elm	T, M, I necrosis Moderate to Severe on all foliage T, M, I necrosis Moderate to Severe on older foliage M, I necrosis Light to Moderate on most leaves
6	450 m E	Norway maple	Foliage in normal condition
8	150 m SE	Silver maple Norway maple	T, M, I necrosis Light to Moderate on most foliage T, M necrosis Severe on most foliage
9	300 m SE	Silver maple Norway maple	T, M necrosis Trace to very Light on most foliage T, M necrosis Light to Moderate on most foliage
10	150 m SSW	Silver maple	T necrosis Trace on most foliage
12	125 m WSW	Manitoba maple Wild grape	M, I necrosis Moderate to Severe on most foliage T, M necrosis Light to Severe on some foliage
14	600 m SW	Norway maple	M, I necrosis Trace to Severe on most foliage
16	60 m N	Amur maple Norway maple Wild grape	M necrosis Moderate to Severe on most foliage T, M, I necrosis Moderate to Severe on most foliage T, M necrosis Trace to Light on some foliage
T - Terminal M - Marginal I - Intercostal Trace - 0-1% Light - 2-10% Moderate - 11-35% Severe - >35%			

Table 1 Cont'd: Observed Injury to Vegetation: American Standard (1995).			
Site No.	**Distance from A-S in meters**	**Vegetation Examined**	**Observations**
17	250 m W	Silver maple Manitoba maple Wild grape	T necrosis Trace on some foliage Foliage in normal condition Foliage in normal condition
18*	1,200 m WNW	Silver maple Norway maple Manitoba maple	Foliage in normal condition Foliage in normal condition Foliage in normal condition
19	850 m N	Norway	T necrosis Trace on few leaves
24	500 m NW	Manitoba Norway	Foliage in normal condition T necrosis Trace on few leaves
28	500 m NNW	Norway maple Amur maple Manitoba maple Wild grape	T, M necrosis Trace to Light on some leaves T, M, I necrosis Trace to Light on older foliage Foliage in normal condition Foliage in normal condition
T - Terminal M - Marginal I - Intercostal *Control Site Trace - 0-1% Light - 2-10% Moderate - 11-35% Severe - >35%			

Table 2: Results of Tree Foliage Analysis: American Standard (1995).								
Site No.	Distance from A-S in meters	Maple Species	Concentration* in Foliage					
			Fluoride	Barium	Boron	Cadmium	Chromium	Cobalt
Sites 0 to 250 m								
16	60 m N	Amur Norway	24 22	18 28	***765*** ***695***	0.1 W 0.1 W	0.5 W 0.5 W	0.3 T 0.2 W
12	125 m WSW	Manitoba	***170***	40	***1055***	0.1 W	0.5 W	0.4 T
8	150 m SE	Silver	***42***	16	***465***	0.1 W	0.5 W	0.2 W
10	150 m SSW	Silver	19	7	***250***	0.1 W	0.5 W	0.2 W
1	200 m NE	Manitoba Norway	***130*** ***58***	54 42	***725*** ***500***	0.1 W 0.1 W	0.6 T 0.5 W	0.3 T 0.2 W
5	225 m E	Norway	29	17	***525***	0.1 W	0.5 W	0.2 W
17	250 m W	Manitoba Silver	17 11	15 21	***245*** ***275***	0.1 W 0.2 T	0.8 T 0.5 W	0.3 T 0.2 W
Mean			***52***	26	***550***	**0.1 W**	**0.5 W**	**0.2 W**
Sites 250 to 500 m								
9	300 m SE	Silver	***67***	16	***280***	0.1 W	0.5 W	0.2 W
2	400 m NE	Norway	30	17	***515***	0.1 W	1.4 T	0.2 W
6	450 m E	Norway	4	7	130	0.1 W	0.5 W	0.2 W
24	500 m NW	Manitoba	10	9	115	0.1 W	0.9 T	0.2 W
28	500 m NNW	Norway	4	9	***255***	0.2 T	0.5 W	0.3 T
Mean			23	12	***259***	**0.1 W**	**0.6 T**	**0.1 W**
Sites >500 m								
3	600 m NE	Norway	7	13	***305***	0.1 W	0.5 W	0.2 W
14	600 m SW	Norway	9	27	***230***	0.1 W	0.5 W	0.2 W
4	700 m NE	Silver	8	6	94	0.1 W	0.5 W	0.2 W
19	850 m N	Norway	2	12	78	0.1 W	0.5 W	0.2 W
18**	1,200 m WNW	Manitoba Norway Silver	5 3 5	11 14 4	115 48 50	0.1 W 0.1 W 0.1 W	0.5 W 0.5 W 0.5 W	0.2 W 0.2 W 0.2 W
Mean (Control Site 18 Excluded)			7	15	***177***	**0.1 W**	**0.3 W**	**0.1 W**
ULN Guideline* **			35	NG	175	2	8	2

* µg/g dry weight, mean of duplicate samples and analysis. ** Upwind control.
*** Phytotoxicology Section Upper Limit of Normal (ULN), see appendix. Underlined results in bold italics exceed ULN. **NG** - ULN not established. **T** - Trace amount. W - Foliar concentration at or below analytical detection limit. In calculating means, "W" values were divided in half.

Table 2 Cont'd: Results of Tree Foliage Analysis: American Standard (1995).

Site No.	Distance from A-S in meters	Maple Species	Concentration* in Foliage					
			Copper	Lead	Molybdenum	Nickel	Strontium	Zinc
Sites 0 to 250 m								
16	60 m N	Amur Norway	8 7	0.7 T 0.6 T	0.2 W ***<u>1.8</u>***	2.8 2.4	41 54	43 33
12	125 m WSW	Manitoba	12	0.5 W	0.4 T	3.2	115	82
8	150 m SE	Silver	8	0.5 W	0.2 W	1.5 T	18	37
10	150 m SSW	Silver	3	0.5 W	0.2 W	0.5 W	34	21
1	200 m NE	Manitoba Norway	6 5	1.2 1.0 T	0.3 T 0.3 T	3.7 1.6 T	66 43	27 25
5	225 m E	Norway	6	1.4 T	0.4 T	0.9 T	42	28
17	250 m W	Manitoba Silver	6 5	0.7 T 1.3 T	0.4 T 0.2 W	1.6 T 1.1 T	89 130	28 51
Mean			**7**	**0.8 T**	**0.4 T**	**1.9**	**63**	**38**
Sites 250 to 500 m								
9	300 m SE	Silver	6	0.7 T	0.2 W	1.0 T	56	63
2	400 m NE	Norway	7	1.7	1.5	0.9	100	30
6	450 m E	Norway	7	0.5 W	0.4 T	0.5 W	54	17
24	500 m NW	Manitoba	10	1.2 T	0.4 T	1.7 T	29	35
28	500 m NNW	Norway	3	0.5 W	0.3 T	0.5 W	33	16
Mean			**7**	**0.8 T**	**0.5 T**	**0.8 T**	**54**	**32**
Sites >500 m								
3	600 m NE	Norway	5	0.5 W	0.2 W	0.5 W	44	24
14	600 m SW	Norway	5	1.1 T	0.2 W	0.5 W	52	34
4	700 m NE	Silver	5	0.5 W	0.2 W	0.5 W	17	39
19	850 m N	Norway	6	0.5 W	0.2 W	0.5 W	49	15
18**	1,200 m WNW	Manitoba Norway Silver	5 4 9	0.9 T 0.5 W 0.9 T	0.2 W 0.2 W 0.2 W	0.5 W 0.5 W 0.5 W	42 88 26	15 15 36
Mean (Control Site 18 Excluded)			**5**	**0.5 T**	**0.2 W**	**0.3 W**	**41**	**28**
ULN Guideline* **			**20**	**60**	**1.5**	**7**	**NG**	**250**

* µg/g dry weight, mean of duplicate samples and analysis. ** Upwind control.
*** Phytotoxicology Section Upper Limit of Normal (ULN), see appendix. Underlined results in bold italics exceed ULN. **NG** - ULN not established. **T** - Trace amount. **W** - Foliar concentration at or below analytical detection limit. In calculating means, "W" values were divided in half.

Table 3: Boron Concentrations in Foliage at Common Sites Sampled Each Year: American Standard (1989 to 1995).

Site No.	Distance from A-S in meters	Maple Species	Concentration* in Foliage			
			1989	1990	1991	1995
Sites 0 to 250 m						
16	60 m N	Amur	***1,300***	***1,050***	***1,000***	***765***
8	150 m SE	Silver	***595***	***605***	***625***	***465***
10	150 m SSW	Silver	***255***	***230***	***245***	***250***
1	200 m NE	Manitoba[1]	***895***	***525***	***625***	***725***
5	225 m E	Norway	***645***	***305***	***515***	***525***
17	250 m W	Silver	***335***	***295***	***320***	***275***
Mean			***671***	***502***	***555***	***501***
Sites 250 to 500 m						
9	300 m SE	Silver	***240***	***365***	***515***	***280***
2	400 m NE	Norway	***395***	***525***	***745***	***515***
6	450 m E	Norway	175	140	165	130
Mean			***270***	***343***	***475***	***308***
Sites >500 m						
3	600 m NE	Norway	***270***	155	***280***	***305***
14	600 m SW	Norway	***270***	155	***200***	***230***
4	700 m NE	Silver	115	103	145	94
18 (Control)	1,200 m WNW	Norway Silver	48 27	38 47	51 35	48 50
Mean (Excluding Controls)			***218***	138	***208***	***210***
ULN Guideline**			175			

*µg/g dry weight, mean of duplicate samples and analysis. [1] Amur maple was sampled prior to 1995.
**Phytotoxicology Section Upper Limit of Normal (ULN) urban guideline, see appendix A.
Note: Results in bold italics and underlined exceed ULN.

Table 4: Fluoride Concentrations in Foliage at Common Sites Sampled Each Year: American Standard (1989 to 1995).

Site No.	Distance from A-S in meters	Maple Species	Concentration* in Foliage			
			1989	1990	1991	1995
Sites 0 to 250 m						
16	60 m N	Amur	33	6	15	24
8	150 m SE	Silver	***<u>67</u>***	35	***<u>44</u>***	***<u>42</u>***
10	150 m SSW	Silver	8	7	15	19
1	200 m NE	Manitoba[1]	***<u>68</u>***	***<u>41</u>***	***<u>57</u>***	***<u>130</u>***
5	225 m E	Norway	31	12	32	29
17	250 m W	Silver	14	7	10	11
Mean			***<u>37</u>***	**18**	**29**	***<u>43</u>***
Sites 250 to 500 m						
9	300 m SE	Silver	20	29	34	***<u>67</u>***
2	400 m NE	Norway	12	12	22	30
6	450 m E	Norway	6	3	7	4
Mean			**13**	**15**	**21**	**34**
Sites >500 m						
3	600 m NE	Norway	3	3	5	7
14	600 m SW	Norway	8	4	7	9
4	700 m NE	Silver	4	8	17	8
18 (Control)	1,200 m WNW	Norway Silver	2 4	2 2	4 4	3 5
Mean (Excluding Controls)			**5**	**5**	**10**	**8**
ULN Guideline**			35			

*µg/g dry weight, mean of duplicate samples and analysis. [1]Amur maple was sampled prior to 1995.
**Phytotoxicology Section Upper Limit of Normal (ULN) urban guideline, see appendix A.
Note: Results in bold italics and underlined exceed ULN.

Table 5: Barium Concentrations in Foliage at Common Sites Sampled Each Year: American Standard (1989 to 1995).

Site No.	Distance from A-S in meters	Maple Species	Concentration* in Foliage			
			1989	1990	1991	1995
Sites 0 to 250 m						
16	60 m N	Amur	3	28	21	18
8	150 m SE	Silver	17	26	19	16
10	150 m SSW	Silver	5	9	11	7
1	200 m NE	Manitoba[1]	48	58	50	54
5	225 m E	Norway	17	18	26	17
17	250 m W	Silver	20	18	18	21
Mean			**18**	**26**	**24**	**22**
Sites 250 to 500 m						
9	300 m SE	Silver	9	21	17	16
2	400 m NE	Norway	9	16	21	17
6	450 m E	Norway	7	6	7	7
Mean			**8**	**14**	**15**	**13**
Sites >500 m						
3	600 m NE	Norway	10	9	14	13
14	600 m SW	Norway	20	14	23	27
4	700 m NE	Silver	4	6	7	6
18 (Control)	1,200 m WNW	Norway Silver	8 3	8 4	9 3	14 4
Mean (Excluding Controls)			**11**	**10**	**15**	**15**
ULN Guideline**			**NG**			

* µg/g dry weight, mean of duplicate samples and analysis. [1] Amur maple was sampled prior to 1995.
** Phytotoxicology Section Upper Limit of Normal (ULN) urban guideline, see appendix A. **NG** - ULN not established.

Table 6: Copper Concentrations in Foliage at Common Sites Sampled Each Year: American Standard (1989 to 1995).

Site No.	Distance from A-S in meters	Maple Species	Concentration* in Foliage			
			1989	1990	1991	1995
Sites 0 to 250 m						
16	60 m N	Amur	10	7	7	8
8	150 m SE	Silver	7	9	8	8
10	150 m SSW	Silver	4	3	2 T	3
1	200 m NE	Manitoba[1]	8	6	7	6
5	225 m E	Norway	6	5	5	6
17	250 m W	Silver	5	4	3 T	5
Mean			**7**	**6**	**5**	**6**
Sites 250 to 500 m						
9	300 m SE	Silver	4	6	6	6
2	400 m NE	Norway	6	6	5	7
6	450 m E	Norway	5	6	7	7
Mean			**5**	**6**	**6**	**7**
Sites >500 m						
3	600 m NE	Norway	3	3	3 T	5
14	600 m SW	Norway	5	4	5	5
4	700 m NE	Silver	5	3	3	5
18 (Control)	1,200 m WNW	Norway Silver	5 4	4 4	3 4	4 9
Mean (Excluding Controls)			4	**3**	4	**5**
ULN Guideline**			20			

* µg/g dry weight, mean of duplicate samples and analysis. **T** - Trace amount. [1] Amur maple was sampled prior to 1995.
** Phytotoxicology Section Upper Limit of Normal (ULN) urban guideline, see appendix A.

Table 7: Lead Concentrations in Foliage at Common Sites Sampled Each Year: American Standard (1989 to 1995).

Site No.	Distance from A-S in meters	Maple Species	Concentration* in Foliage			
			1989	1990	1991	1995
Sites 0 to 250						
16	60 m N	Amur	<4	<3	2 T	1 T
8	150 m SE	Silver	<1	<1	3 T	0.5 W
10	150 m SSW	Silver	<1	<1	1 T	0.5 W
1	200 m NE	Manitoba[1]	<2	<3	3 T	1 T
5	225 m E	Norway	<2	<2	2 T	1 T
17	250 m W	Silver	<3	<2	1 T	1 T
Mean			**<2**	**<2**	**<2**	**1 T**
Sites 250 to 500 m						
9	300 m SE	Silver	<1	<1	1 T	1 T
2	400 m NE	Norway	<2	<1	2 T	2
6	450 m E	Norway	<1	<2	1 T	0.5 W
Mean			<1	<1	**1 T**	**1 T**
Sites >500 m						
3	600 m NE	Norway	<1	<1	1 T	0.5 W
14	600 m SW	Norway	2	<2	2 T	1 T
4	700 m NE	Silver	<1	<1	2 T	0.5 W
18 (Control)	1,200 m WNW	Norway Silver	<1 <1	<1 <1	0.5 W 0.5 W	0.5 W 1 T
Mean (Excluding Controls)			<1	<1	**2 T**	**0.5 T**
ULN Guideline**			60			

* µg/g dry weight, mean of duplicate samples and analysis. < Less than. [1] Amur maple was sampled prior to 1995.
** Phytotoxicology Section Upper Limit of Normal (ULN) urban guideline, see appendix A. **T** - Trace amount.
W - Concentration at or below analytical detection limit. In calculating means, "W" values were divided in half.

Table 8: Nickel Concentrations in Foliage at Common Sites Sampled Each Year: American Standard (1989 to 1995).

Site No.	Distance from A-S in meters	Maple Species	Concentration* in Foliage			
			1989	1990	1991	1995
Sites 0 to 250 m						
16	60 m N	Amur	***<u>9</u>***	4	3 T	3
8	150 m SE	Silver	2	3	2 T	2 T
10	150 m SSW	Silver	1	1	2 T	0.5 W
1	200 m NE	Manitoba[1]	6	7	***<u>9</u>***	4
5	225 m E	Norway	3	3	3 T	1 T
17	250 m W	Silver	2	2	1 T	1 T
Mean			**4**	**3**	**3 T**	**2 T**
Sites 250 to 500 m						
9	300 m SE	Silver	1	2	2 T	1 T
2	400 m NE	Norway	1	2	4	1 T
6	450 m E	Norway	1	1	2 T	0.5 W
Mean			**1**	**2**	**3 T**	**1 T**
Sites >500 m						
3	600 m NE	Norway	1	1	3	0.5 W
14	600 m SW	Norway	1	2	2 T	0.5 W
4	700 m NE	Silver	1	1	2 T	0.5 W
18 (Control)	1,200 m WNW	Norway Silver	1 1	1 1	2 T 2 T	0.5 W 0.5 W
Mean (Excluding Controls)			**1**	**1**	**2 T**	**0.5 W**
ULN Guideline**			7			

*µg/g dry weight, mean of duplicate samples and analysis. [1] Amur maple was sampled prior to 1995.
Phytotoxicology Section Upper Limit of Normal (ULN) urban guideline, see appendix A. Note: Results in bold italics and underlined exceed ULN. **T - Trace amount.
W - Concentration at or below analytical detection limit. In calculating means, "W" values were divided in half.

Table 9: Zinc Concentrations in Foliage at Common Sites Sampled Each Year: American Standard (1989 to 1995).						
Site No.	Distance from A-S in meters	Maple Species	Concentration* in Foliage			
			1989	1990	1991	1995
Sites 0 to 250 m						
16	60 m N	Amur	56	55	71	43
8	150 m SE	Silver	56	77	47	37
10	150 m SSW	Silver	26	29	24	21
1	200 m NE	Manitoba[1]	53	56	21	27
5	225 m E	Norway	26	33	37	28
17	250 m W	Silver	83	73	43	51
Mean			**50**	**54**	**41**	**35**
Sites 250 to 500 m						
9	300 m SE	Silver	36	79	77	63
2	400 m NE	Norway	32	30	26	30
6	450 m E	Norway	12	12	15	17
Mean			**27**	**40**	**39**	**37**
Sites >500 m						
3	600 m NE	Norway	17	13	17	24
14	600 m SW	Norway	26	21	28	34
4	700 m NE	Silver	33	31	37	39
18 (Control)	1,200 m WNW	Norway Silver	13 24	15 21	13 28	15 36
Mean (Excluding Controls)			**25**	**22**	**27**	**32**
ULN Guideline**			250			

* µg/g dry weight, mean of duplicate samples and analysis. [1] Amur maple was sampled prior to 1995.
** Phytotoxicology Section Upper Limit of Normal (ULN) urban guideline, see appendix A.

Table 10: Soil Analysis Results*: American Standard (1995)

Element	Depth (cm)	Sites 0-250 m (order of increasing distance from A-S)								Sites 250 to 500 m				Sites >500 m			Control Site 18	ULN or OTR
		16	12	8	10	1	5	17	Mean	9	2	28	Mean	3	14	Mean		
Barium	0-5	***190***	120	160	71	***190***	85	125	**134**	87	107	76	**90**	73	40	**57**	70	**160****
	25-30	53	NR	NR	39	130	90	NR		70	54	65		50	NR		70	
Boron	0-5	***25***	***48***	***28***	9	***39***	8	***18***	**25**	***17***	***17***	12	**15**	10	6	**8**	4	**15**
	25-30	9	NR	NR	5	***24***	10	NR		10	9	10		4	NR		5	
Cadmium	0-5	0.9T	0.8T	0.8T	0.5T	1.0	0.9T	1.0T	**0.8T**	0.6T	0.7T	1.1T	**0.8T**	1.0T	0.5T	**0.8T**	0.9T	**4**
	25-30	0.7T	NR	NR	0.5T	1.1	0.9T	NR		0.5T	0.4T	0.9T		0.5T	NR		1.2	
Chromium	0-5	24	14	16	15	18	15	15	**17**	13	17	20	**17**	15	10	**13**	19	**50**
	25-30	14	NR	NR	11	23	16	NR		12	15	17		11	NR		18	
Cobalt	0-5	7	10	8	5	16	7	7	**9**	7	9	6	**7**	6	3	**5**	6	**25**
	25-30	5	NR	NR	4	8	7	NR		5	5	6		4	NR		7	
Copper	0-5	51	24	36	19	33	18	24	**29**	21	19	20	**20**	17	17	**17**	19	**100**
	25-30	15	NR	NR	16	25	19	NR		21	9	16		10	NR		20	
Lead	0-5	55	51	48	69	100	86	205	**88**	50	92	117	**86**	104	42	**73**	38	**500**
	25-30	25	NR	NR	24	190	160	NR		50	33	81		51	NR		48	
Molybdenum	0-5	0.6T	DL	DL	DL	DL	DL	DL	**DL**	DL	DL	DL	**DL**	DL	DL	**DL**	DL	**3**
	25-30	DL	NR	NR	DL	DL	DL	NR		DL	DL	0.6T		DL	DL		DL	
Nickel	0-5	48	25	38	11	40	17	19	**28**	19	22	14	**18**	12	8	**10**	14	**60**
	25-30	13	NR	NR	8	17	13	NR		11	9	11		7	NR		18	
Strontium	0-5	40	26	50	64	53	29	62	**46**	53	21	37	**37**	28	74	**51**	57	**78****
	25-30	24	NR	NR	***96***	49	36	NR		76	21	36		48	NR		60	
Vanadium	0-5	25	27	25	26	29	29	28	**27**	20	29	29	**26**	29	16	**23**	29	**70**
	25-30	27	NR	NR	21	27	28	NR		21	27	27		24	NR		35	
Zinc	0-5	155	130	125	125	185	155	***575***	**207**	120	130	215	**155**	170	104	**137**	135	**500**
	25-30	110	NR	NR	55	215	175	NR		96	74	180		115	NR		160	

*µg/g dry wt., mean of duplicate samples and analysis. **ULN** - Phytotoxicology Section Upper Limit of Normal (ULN) urban guidelines (Appendix A). **OTR** Ontario Typical Range (Appendix B).
**OTR substituted for ULN (no ULN available) Note: Results in bold italics and underlined exceed ULN or OTR.
DL - Concentration at or below analytical detection limit.. **T** - Trace amount. **NR** - No result, not sampled.

Table 11: Results* for Common Elements in Surface Soil (0-5 cm) at Comparable Sites within 500 m of American Standard (1989 and 1995).

Site	Barium		Boron		Copper		Lead		Nickel		Zinc	
	1989	1995	1989	1995	1989	1995	1989	1995	1989	1995	1989	1995
Comparable Sites												
2	105	107	***26***	***17***	21	19	76	92	23	22	115	130
8	104	160	***22***	***28***	22	36	27	48	24	38	95	125
9	60	87	14	***17***	17	21	24	50	14	19	78	120
10	85	71	15	9	22	19	63	69	17	11	140	125
16	125	***190***	***29***	***25***	27	51	24	55	32	48	110	155
Mean	**96**	**123**	***21***	***19***	**22**	**29**	**43**	**63**	**22**	**28**	**108**	**131**
Excluded Non Comparable Sites												
1	***310***	***190***	***130***	***39***	72	33	235	100	***70***	40	270	185
5	72	85	13	8	16	18	41	86	17	17	94	155
12	109	120	***56***	***48***	58	24	91	51	36	25	180	130
17	***355***	125	***240***	***18***	***190***	24	***620***	205	***115***	19	***865***	***575***
ULN or OTR	**160****		**15**		**100**		**500**		**60**		**500**	

*µg/g dry wt., mean of duplicate samples and analysis. **OTR substituted for ULN (no ULN available).
ULN - Phytotoxicology Section Upper Limit of Normal (ULN) urban guidelines, see Appendix A.
OTR - Ontario Typical Range urban guidelines, see Appendix B. Note: Results in bold italics and underlined exceed ULN or OTR.

Table 12: Summary of Soil Boron Data: American Standard (1989 & 1995).

Site	Distance from A-S in meters	Sampling Depth (cm)	Total and Available Concentrations in Soil*				
			Total Boron		HWE Available Boron		
			1989	1995	1989 Old Method	1995 Old Methed	1995 New Method
Sites within 250 m							
16	60 m N	0-5 15-25	***29*** NR	***25*** 9	***2.4*** 0.5	***1.6*** ***1.8***	***3.8*** ***3.2***
12**	125 m WSW	0-5	***56***	***48***	***1.1***	***1.4***	***2.6***
8	150 m SE	0-5	***22***	***28***	1.0	***2.3***	***4.7***
10	150 m SSW	0-5 25-30	15 NR	9 5	0.7 0.4	0.8 0.5	***1.8*** 0.8
1**	200 m NE	0-5 25-30	***130*** NR	***39*** ***24***	***3.7*** ***1.8***	***2.3*** ***2.8***	***5.4*** ***5.8***
5**	225 m E	0-5 25-30	13 NR	8 10	0.8 0.4	0.7 0.7	1.4 1.1
17**	250 m W	0-5	***240***	***18***	0.5	***1.8***	***2.7***
Sites 250 to 500 m							
9	300 m SE	0-5 25-30	14 NR	***17*** 10	0.5 0.4	***1.5*** ***1.3***	***3.2*** ***2.3***
2	400 m NE	0-5 25-30	***26*** NR	***17*** 9	***1.2*** 0.8	***1.3*** ***1.4***	***2.8*** ***2.3***
28	500 m NNW	0-5 25-30	NR NR	12 10	NR NR	0.7 0.7	1.5 ***1.7***
Sites > 500 m							
3	600 m NE	0-5 15-25	10 NR	10 4	0.4 0.3	0.7 0.5	1.2 0.6
14	600 m SW	0-5	5	6	0.2	0.6	1.0
18***	1,200 m WNW	0.5 15-25	3 NR	4 5	0.1 0.1	0.3 0.1	0.6 <0.02W
Corresponding Phytotoxicology Guidelines			15	15	1	1	1.5

* ug/g, dry weight, mean of duplicate samples and analysis. NR - No result, soil not collected. *** Control Site
** Results for 1989 and 1995 are not comparable (may not be precisely the same sample site).
HWE - Hot water extractable. Note: Results in bold italics and underlined exceed MOEE guidelines.

Table 13: Summary of Soil and Foliage Boron Data and Foliar Injury at Sites where Both Foliage and Soil was Analyzed: American Standard (1995).

Site	Distance from A-S in meters	Boron Concentration* In Soil and Maple Foliage (1995)				
		Soil (0-5 cm / 25-30 cm)			Maple Foliage	
		Total Boron	HWE Old Method	HWE New Method	Total Boron	Injury to Foliage
Sites within 250 m						
16	60 m N	***25*** 9	***1.6*** ***1.8***	***3.8*** ***3.2***	Amur ***765*** Norway ***695***	Moderate to Severe
12	125 m WSW	***48***	***1.4***	***2.6***	Manitoba ***1,055***	Moderate to Severe
8	150 m SE	***28***	***2.3***	***4.7***	Silver ***465***	Light to Severe
10	150 m SSW	9 5	0.8 0.5	***1.8*** 0.8	Silver ***250***	Trace
1	200 m NE	***39*** ***24***	***2.3*** ***2.8***	***5.4*** ***5.8***	Manitoba ***725*** Norway ***500***	Light to Severe
5	225 m E	8 10	0.7 0.7	1.4 1.1	Norway ***525***	Moderate to Severe
17	250 m W	***18***	***1.8***	***2.7***	Manitoba ***245*** Silver ***275***	Trace
Sites 250 to 500 m						
9	300 m SE	***17*** *10*	***1.5*** ***1.3***	***3.2*** ***2.3***	Silver ***280***	Trace to Moderate
2	400 m NE	***17*** 9	***1.3*** ***1.4***	***2.8*** ***2.3***	Norway ***515***	Light to Moderate
28	500 m NNW	12 10	0.7 0.7	1.5 ***1.7***	Norway ***255***	Trace to Light
Sites > 500 m						
3	600 m NE	10 4	0.7 0.5	1.2 0.6	Norway ***305***	Light to Severe
14	600 m SW	6	0.6	1.0	Norway ***230***	Trace to Severe
18	Control 1,200 m WNW	4 5	0.3 0.1	0.6 <0.02W	Manitoba 115 Norway 48 Silver 50	No Injury
MOEE Guidelines		15	1	1.5	175	NG

* ug/g, dry weight, mean of duplicate samples and analysis. W - Concentration at or below analytical detection limit.
HWE - Hot water extractable. Note: Results in bold italics and underlined exceed Phytotoxicology guidelines. NG - No guideline.
Injury Categories - Trace 0-1%, Light 2-10%, Moderate 11-35%, Severe >35%.

Appendix A

Derivation and Significance of the MOEE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines.

The MOEE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (reference: *Ontario Ministry of the Environment. 1989. Ontario Ministry of the Environment "Upper Limit of Normal" Contaminant Guidelines for Phytotoxicology Samples. Phytotoxicology Section, Air Resources Branch: Technical Support Sections NE and NW Regions, Report No. ARB-138-88-Phyto. ISBN: 0-7729-5143-8.).* Chemical analyses were conducted by the MOEE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOEE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.

Appendix B

Derivation and Significance of the Ontario Ministry of Environment and Energy (MOEE) "Ontario Typical Range" of Chemical Parameters in Soil, Vegetation, Moss bags and Snow

The MOEE "Ontario Typical Range" (OTR) guidelines are being developed to assist in interpreting analytical data and evaluating source-related impacts on the terrestrial environment. The OTRs are used to determine if the level of a chemical parameter in soil, plants, moss bags, or snow is significantly greater than the normal background range. An exceedence of the OTR_{98} (*the OTR_{98} is the actual guideline number*) may indicate the presence of a potential point source of contamination.

The OTR_{98} represents the expected range of concentrations of chemical parameters in surface soil, plants, moss bags, and snow from areas in Ontario not subjected to the influence of known point sources of pollution. The OTR_{98} represents 97.5 percent of the data in the OTR distribution. This is equivalent to the mean plus two standard deviations, which is similar to the previous MOEE "Upper Limit of Normal" (ULN) guidelines. In other words, 98 out of every 100 background samples should be lower than the OTR_{98}.

The OTR_{98} may vary between land use categories even in the absence of a point source of pollution because of natural variation and the amount and type of human activity, both past and present. Therefore, OTRs are being developed for several land use categories. The three main land use categories are Rural, New Urban, and Old Urban. Urban is defined as an area that has municipal water and sewage services. Old Urban is any area that has been developed as an urban area for more than 40 years. Rural is all other areas. These major land use categories are further broken into three subcategories; Parkland (which includes greenbelts and woodlands), Residential, and Industrial (which includes heavy industry, commercial properties such as malls, and transportation rights-of-way). Rural also includes an Agricultural category.

The OTR guidelines apply only to samples collected using standard MOEE sampling, sample preparation, and analytical protocols. Because the background data were collected in Ontario, the OTRs represent Ontario environmental conditions.

The OTRs are not the only means by which results are interpreted. Data interpretation should involve reviewing results from control samples, examining all the survey data for evidence of a pattern of contamination relative to the suspected source, and where available, comparison with effects-based guidelines. The OTRs are particularly useful where there is uncertainty regarding local background concentrations and/or insufficient samples were collected to determine a contamination gradient. OTRs are also used to determine where in the anticipated range a result falls. This can identify a potential concem even when a result falls within the guideline. For example, if all of the results from a survey

are close to the OTR_{98} this could indicate that the local environment has been contaminated above the *anticipated average,* and therefore the pollution source should be more closely monitored.

The OTRs identify a range of chemical parameters resulting from natural variation and normal human activity. ***As a result, it must be stressed that values falling within a specific OTR_{98} should not be considered as acceptable or desirable levels; nor does the OTR_{98} imply toxicity to plants, animals or humans.*** Rather, the OTR_{98} is a level which, if exceeded, prompts further investigation on a case by case basis to determine the significance, if any, of the above normal concentration. Incidental, isolated or spurious exceedences of an OTR_{98} do not necessarily indicate a need for regulatory or abatement activity. However, repeated and/or extensive exceedences of an OTR_{98} that appears to be related to a potential pollution source does indicate the need for a thorough evaluation of the regulatory or abatement program.

The OTR_{98} supersedes the Phytotoxicology ULN guideline. The OTR program is on-going. The number of OTRs will be continuously updated as sampling is completed for the various land use categories and sample types.